

# CROP QUALITY & UTILIZATION

## Nitrogen Fertilization of Buffalograss

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### ABSTRACT

Because native, shortgrass prairies are not typically fertilized and otherwise extensively managed, little information is available on their response to nitrogen (N) fertilization. An experiment was conducted in 1997 and 1998 to study the effects of N fertilization on forage yield and quality, forage height, and subsequent nitrate accumulation in the soil of a rangeland site consisting primarily of buffalograss [*Buchloe dactyloides* (Nutt.) Engelm.]. The N treatments were 0, 34, 68, 102, and 136 kg ha<sup>-1</sup> arranged in a Latin square design. An increase ( $P < 0.05$ ) in forage dry matter (DM) yield was obtained with 34 kg ha<sup>-1</sup> N. Greater ( $P < 0.05$ ) forage yields were achieved with an additional 102 kg ha<sup>-1</sup> N (total 136 kg ha<sup>-1</sup> N). Forage yields averaged 2540 kg ha<sup>-1</sup> in 1997 and 2340 kg ha<sup>-1</sup> in 1998. Nitrogen fertilization increased crude protein (CP) of buffalograss forage. Each unit of 34 kg ha<sup>-1</sup> N linearly increased CP up to approximately 122 g kg<sup>-1</sup> of DM forage. Weather conditions influenced in vitro digestible dry matter (IVDDM). As long as moisture conditions were favorable for forage growth, IVDDM increased linearly with N fertilization rate. In 1997, IVDDM ranged from 565 g kg<sup>-1</sup> for the control to 658 g kg<sup>-1</sup> for the 102 kg ha<sup>-1</sup> N application rate. In 1998, IVDDM declined linearly ( $P < 0.05$ ) with N fertilization rate. In vitro digestible dry matter averaged 539 g kg<sup>-1</sup> for the control to 482 g kg<sup>-1</sup> for the 136 kg ha<sup>-1</sup> N application rate. Nitrogen fertilization of buffalograss dominated semiarid rangeland can enhance forage production and quality. Nitrate accumulation in the soil was insignificant over the study period.

A NUMBER OF FERTILIZATION TRIALS have been conducted on native and reseeded rangeland sites in the Great Plains (Huffine and Elder, 1960; Launchbaugh, 1962; Burzlaff et al., 1968; Warnes and Newell, 1969; Rehm et al., 1972; Pettit and Deering, 1974; Samuel et al., 1980; Gillen et al., 1987; Berg, 1990; Hart et al., 1995; Gillen and Berg, 1998); however, mid- and tall grass species dominated in these studies and results were mixed among experiments. Increases in forage DM production have been achieved with as little as 34 kg ha<sup>-1</sup> N and greater than 100 kg ha<sup>-1</sup> N (Burzlaff et al., 1968; Lorenz and Rogler, 1972). Increases have also been reported for crude protein concentration in forages fertilized with nitrogen (Houston and van der Sluijs, 1975).

Several known benefits can be attributed to fertilization. Forage availability and forage DM intake by livestock increase with increasing N fertilization rate. Burton et al. (1956) with bermudagrass [*Cynodon dactylon* (L.) Pers.] and Cook (1965) with wheatgrass (*Agropyron*

spp.) showed that forage DM intake was positively correlated with N fertilization rate. Fertilization may also increase forage preference by livestock. Cook and Jefferies (1963) showed that cattle grazed previously fertilized areas substantially more than unfertilized areas. Similarly, Hooper et al. (1969) showed that it was feasible to manage for more uniform distribution of forage utilization and increased profitability by fertilizing pasture and range.

Because native shortgrass prairies are typically not fertilized and otherwise extensively managed, little information is available on their response to N fertilization. Thus, the objectives were to study the effect of N fertilization on forage yield and quality, forage height, and nitrate accumulation in the soil of a rangeland site consisting primarily of buffalograss.

### MATERIALS AND METHODS

This study was conducted at the Oklahoma Panhandle Research and Extension Center, Goodwell, OK, (36°35' N, 101°37' W, elevation 992 m) on a Richfield clay loam soil (Fine, smectitic, mesic Aridic Argiustolls). Plots were established on a native, rangeland site consisting primarily of buffalograss (>90% cover). The experiment consisted of four N fertility treatments, 34, 68, 102, and 136 kg ha<sup>-1</sup> N (urea, 46-0-0) and a check (0 kg ha<sup>-1</sup> N). Twenty-five plots (3.3 by 7.5 m) were arranged in a Latin square design. Prior to fertilization the first year, two soil samples were taken from every plot to provide a baseline for nitrate accumulation. Soil was sampled at the 0- to 15- and the 15- to 60-cm depths. Soil samples were tested for nitrate content at the Oklahoma State University Soils Laboratory, Stillwater, OK. Plots were fertilized on 24 June 1997 and on 30 June 1998. Plots were harvested on 26 Aug. 1997 and on 1 Sept. 1998. After harvest each year, soil samples were collected and tested as outlined previously.

At harvest each year forage height was measured on each plot. The forage DM yield of each plot was determined by harvesting a 0.5- by 7.5-m area to a stubble height of 5 cm through the center of each plot. The harvested material was weighed fresh, a 250- to 300-g subsample collected and dried, and DM determined. The total DM of each plot was calculated by multiplying the DM content of the oven-dried sample by the harvested green weight of the plot and converted to kg ha<sup>-1</sup>. Oven-dried samples were ground to pass a 1-mm screen in preparation for analysis of CP concentration and IVDDM. Crude protein concentration was determined by procedures outlined by AOAC (1990). In vitro digestible dry matter was determined with the ANKOM system (ANKOM Technology Corp., Fairport, NY).

Data for forage height, DM production, CP concentration, and IVDDM were analyzed as a Latin square design analysis

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of variance by PROC GLM (SAS Institute, 1988.) The main plot treatment was N-fertilization and the subplot treatment was year. Comparisons of means were made by Fisher's (protected) least significant difference (LSD) at  $P \leq 0.05$  (Steel and Torrie, 1980). Regression models were fit to the data by least squares to obtain the best unbiased estimators of the regression parameters. Regression equations were generated for predicting forage height, DM yield, CP concentration, and IVDDM with N-fertilization rate as the independent variable by PROC REG (SAS Institute, 1988.)

## RESULTS AND DISCUSSION

Differences in forage DM production were attributed to environment (year of production,  $P < 0.04$ ) and nitrogen application rate ( $P < 0.001$ ). Forage DM yield averaged 2540 kg ha<sup>-1</sup> in 1997 and 2340 kg ha<sup>-1</sup> in 1998. It was not surprising to find differences between environments. Near normal rainfall occurred in April, May, and June 1997 while subnormal rainfall occurred for those same months in 1998 (Table 1). Near normal rainfall occurred in July and August 1997 and above normal rainfall occurred during the same period in 1998. Although there was adequate rainfall during July and August of both years, the distribution of rainfall was different. In 1997, rainfall followed a unimodal distribution pattern with summer rainfall beginning the second week of July and ending the fourth week of August. In 1998, rainfall followed a trimodal distribution pattern. The first period of rainfall occurred near the first of July, the second near the first of August, and the third near the first of September. Consequently, buffalograss plant growth was steady in 1997 without long dormancy periods. In 1998, moisture was a limiting factor in the spring and buffalograss growth was intermittent until the first of July. Plant growth occurred in early July after moisture was received. Plants became dormant when moisture became limiting in mid to late July, but plant regrowth occurred after significant rainfall in early August. Moisture again became a limiting factor in mid to late August and plants again went dormant until rainfall in late August.

Forage DM production averaged 1850 kg ha<sup>-1</sup> for the control (no additional N applied) to 2810 kg ha<sup>-1</sup> for 136 kg ha<sup>-1</sup> additional N. A regression equation for DM production ( $Y$ , kg ha<sup>-1</sup>) based on N application rate ( $x$ , kg ha<sup>-1</sup>) was  $Y = 12.1x - 0.04x^2 + 1910$  ( $F = 11.5$ ;

$DF = 2, 47$ ;  $P < 0.001$ ; Fig. 1). Using this equation, we compared our data with that of Houston and van der Sluijs (1975). They used 0, 22, and 45 kg ha<sup>-1</sup> N fertilization rates on a shortgrass prairie consisting primarily of blue grama (*Bouteloua gracilis* Lag.). They found a 18% increase in seasonal DM production compared with a 24% increase for our data at the same N rates.

Although environment by N rate interactions were lacking ( $P > 0.88$ ),  $Y$  intercepts were different ( $P < 0.04$ ) for environments. Regression equations for DM production based on N application rate for environments were as follow:  $Y = 6.5x - 0.06x^2 + 1955$  ( $F = 10.9$ ;  $DF = 2, 22$ ;  $P < 0.001$ ) for 1997 and  $Y = 6.2x - 0.02x^2 + 1870$  ( $F = 3.6$ ;  $DF = 2, 22$ ;  $P < 0.05$ ) for 1998. Differences in regression equation intercepts and coefficients can be explained by environmental conditions discussed previously.

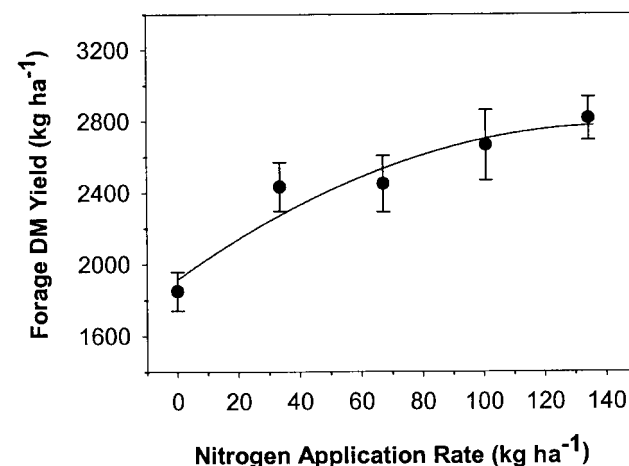
Increased forage height was attributed to nitrogen application rate ( $P < 0.001$ ). Forage height averaged from 4.4 cm for the control to 8.8 cm for plots treated with 136 kg ha<sup>-1</sup> N. Forage height increased with increasing amounts of N. A regression equation for forage height ( $Y$ , cm) based on N application rate was  $Y = 0.03x + 4.6$  ( $F = 91.6$ ;  $DF = 1, 48$ ;  $P < 0.001$ ; Fig. 2).

Nitrogen application rates accounted for significant variation in CP concentration ( $P < 0.001$ ). Crude protein averaged 90 g kg<sup>-1</sup> for the control to 125 g kg<sup>-1</sup> for the 136 kg ha<sup>-1</sup> N application rate. A linear increase in CP concentration occurred with increasing levels of N. The regression equation for CP concentration ( $Y$ , g kg<sup>-1</sup>) based on N application rate was  $Y = 0.27x + 90.4$  ( $F = 116.5$ ;  $DF = 1, 48$ ;  $P < 0.001$ ; Fig. 3). Other investigators have shown nitrogen fertilization to increase CP concentrations of grasses (Houston and van der Sluijs, 1975; Samuel et al., 1980). They found higher rates of increase for blue grama than we found for buffalograss. The rate of increase for CP concentration was 0.55 g kg<sup>-1</sup> for each kg N applied for the experiment by Houston and van der Sluijs (1975) and 0.88 g kg<sup>-1</sup> for each kg N applied for the experiment by Samuel et al. (1980). The rate of increase in our experiment was

**Table 1.** Precipitation (mm) received at the Oklahoma Panhandle Research and Extension Center at Goodwell, OK, in 1997 and 1998.

Month	1997	1998	Average†
January	5.1	2.5	6.9
February	9.6	17.8	10.7
March	0	42.7	22.1
April	82.3	20.6	31.2
May	47.2	18.5	79.0
June	26.9	21.8	68.1
July	48.5	104.1	64.0
August	80.5	65.0	54.9
September	24.6	6.1	42.7
October	21.1	172.0	24.4
November	10.2	21.8	18.5
December	21.8	11.9	7.1

† Average precipitation based on 89 yr of data at Goodwell, OK, Research Station (National Oceanic and Atmospheric Administration, 1997).



**Fig. 1.** Relationship between N application rate ( $x$ ) and forage dry matter (DM) yield ( $Y$ ) for rangeland buffalograss.  $Y = 12.1x - 0.04x^2 + 1910$  ( $F = 11.5$ ;  $DF = 2, 47$ ;  $P < 0.001$ ;  $r^2 = 0.58$ ). Each data point is the mean  $\pm$ SE of 10 experimental units.

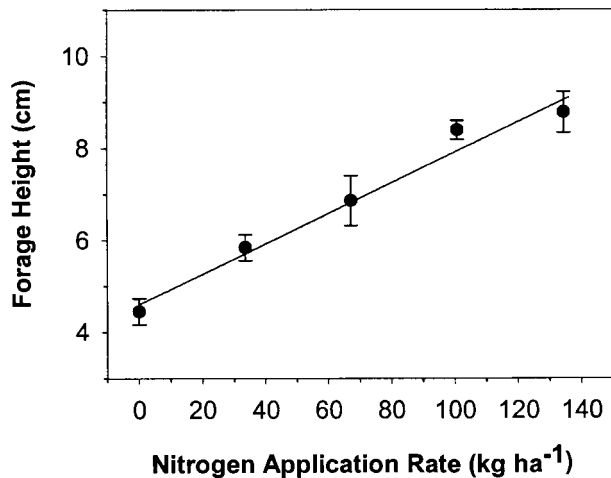


Fig. 2. Relationship between N application rate ( $x$ ) and forage height ( $Y$ ) for rangeland buffalograss.  $Y = 0.03x + 4.6$  ( $F = 91.6$ ;  $DF = 1, 48$ ;  $P < 0.001$ ;  $r^2 = 0.76$ ). Each data point is the mean  $\pm$ SE of 10 experimental units.

0.27 g kg<sup>-1</sup> for each kg N applied. Although buffalograss and blue grama are both shortgrasses, the differences found in the rate of increase in CP concentration is likely due to species differences.

An environment  $\times$  nitrogen application rate interaction ( $P < 0.005$ ) described significant variation for IVDDM. There was a linear increase for IVDDM in 1997. In 1997, IVDDM averaged 565 g kg<sup>-1</sup> for the control to 658 g kg<sup>-1</sup> for the 102 kg ha<sup>-1</sup> N application rate. The regression equation for IVDDM ( $Y$ , g kg<sup>-1</sup>) based on N application rate was  $Y = 0.72x + 559.6$  ( $F = 18.6$ ;  $DF = 1, 23$ ;  $P < 0.001$ ; Fig. 4). A linear decline was found for IVDDM in 1998. In vitro digestible DM averaged 539 g kg<sup>-1</sup> for the control to 482 g kg<sup>-1</sup> for the 136 kg ha<sup>-1</sup> N application rate. The regression equation for 1998 was  $Y = -0.38x + 527.2$  ( $F = 6.2$ ;  $DF = 1, 23$ ;  $P < 0.03$ ; Fig. 4). Seasonal differences in moisture discussed previously presumably accounted for the interaction. In vitro digestible dry matter should increase with supplemental N as long as moisture is not a limiting

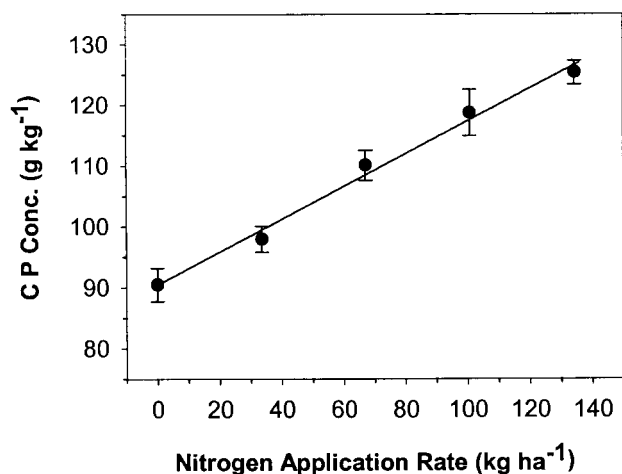


Fig. 3. Relationship between N application rate ( $x$ ) and crude protein concentration ( $Y$ ) for rangeland buffalograss.  $Y = 0.27x + 90.4$  ( $F = 116.5$ ;  $DF = 1, 48$ ;  $P < 0.001$ ;  $r^2 = 0.86$ ). Each data point is the mean  $\pm$ SE of 10 experimental units.

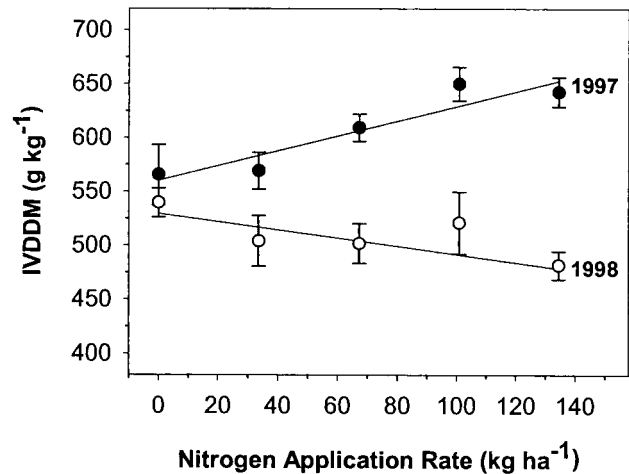


Fig. 4. Relationship between N application rate ( $x$ ) and in vitro digestible dry matter (IVDDM,  $Y$ ) for rangeland buffalograss in years 1997 (closed circle) and 1998 (open circle). In 1997,  $Y = 0.72x + 559.6$  ( $F = 18.6$ ;  $DF = 1, 23$ ;  $P < 0.001$ ;  $r^2 = 0.45$ ). In 1998,  $Y = -0.38x + 527.2$  ( $F = 6.2$ ;  $DF = 1, 23$ ;  $P < 0.03$ ;  $r^2 = 0.25$ ). Each data point is the mean  $\pm$ SE of 10 experimental units.

factor during the growing season, as in 1997. If buffalograss plants go in and out of dormancy due to fluctuating soil moisture, as in 1998, then IVDDM likely declines with N fertilization.

There were no differences ( $P < 0.47$  for both the 0- to 15- and 15- to 60-cm depths) among treatments for soil nitrate accumulation between samples collected at the beginning of the experiment and samples taken at the end of the experiment. At the end of the test period, soil nitrate levels had increased 0.67 kg ha<sup>-1</sup> in the 0- to 15-cm soil depth above that of the check plot where nitrogen was not applied. Soil nitrate levels decreased 0.62 kg ha<sup>-1</sup> below that of the check plot in the 15- to 60-cm soil depth. Further research is needed to determine the long term effects of nitrogen fertilization on possible nitrate accumulation in shortgrass prairie soils.

## CONCLUSIONS

In native shortgrass prairies in the west central Great Plains of the USA, buffalograss and blue grama may comprise 90% or more of the vegetation on non-sandy soils (Wenger, 1943). In this experiment, forage production of a shortgrass prairie consisting primarily of buffalograss was increased with as little as 34 kg ha<sup>-1</sup> of additional N. Even higher yields were possible with an additional 102 kg ha<sup>-1</sup> N (136 kg ha<sup>-1</sup> N total). At low fertilization rates (34 kg ha<sup>-1</sup> N), the ratio of kg DM forage to kg N applied was approximately 17. This ratio dropped to about 8 kg or less of DM forage to kg N applied at fertilization rates greater than or equal to 68 kg ha<sup>-1</sup> N. Nitrogen fertilization of semiarid shortgrass prairies, consisting primarily of buffalograss, with commercial fertilizer at low rates (34 kg ha<sup>-1</sup>) may be economically feasible. Higher fertilization rates may also be economical if the N is from alternative source such as animal waste. Similar to other studies, CP concentration of forage was increased with N fertilization. Crude protein concentration increased linearly at the rate of

0.27 g kg<sup>-1</sup> for each kg of N applied. Weather conditions, particularly rainfall, influenced the degree of digestibility of the forage. As long as moisture conditions are favorable for forage growth, forage digestibility should increase with N fertilization; however, declines in digestibility should be expected when growing conditions are unfavorable. Nitrate accumulation in the soil did not occur over the study period, but, further research is needed to determine the long-term effects of nitrogen fertilization on possible nitrate accumulation in shortgrass prairie soils.

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